

The claimed invention is:

1. A process for the production of at least one of gamma-butyrolactone, 1,4-butanediol and tetrahydrofuran comprising:

(A) a first hydrogenation zone and a second hydrogenation zone connected in series,

(B) supplying to the first hydrogenation zone a feedstream comprising maleic acid,

(C) reacting in the first hydrogenation zone, the maleic acid feedstock and hydrogen in contact with a catalyst to produce a reaction product comprising succinic acid,

(D) supplying to the second hydrogenation zone, the reaction product of the first hydrogenation zone,

(E) reacting in the second hydrogenation zone, the reaction product from the first hydrogenation zone and hydrogen in contact with a catalyst to produce a product stream comprising at least one of gamma-butyrolactone, 1,4-butanediol and tetrahydrofuran,

wherein the temperature of the feedstream comprising maleic acid and the temperature of the first hydrogenation zone are controlled such that the temperature of maleic acid in the feedstream and the first hydrogenation zone does not exceed about 130°C.

2. The process of claim 1, wherein the temperature of the feedstream comprising maleic acid and the temperature of the first hydrogenation zone are controlled such that the temperature of maleic acid in the feedstream and the first hydrogenation zone does not exceed about 120°C.

3. The process of claim 1, wherein the temperature of the feedstream comprising maleic acid and the temperature of the first hydrogenation zone are controlled such that the temperature of maleic acid in the feedstream and the first hydrogenation zone does not exceed about 100°C.

4. The process of claim 1, wherein heat is added to the reaction product from the first hydrogenation zone to raise the reaction product to a temperature above about 130°C prior to supplying the reaction product from the first hydrogenation zone to the second hydrogenation zone.

5. The process of claim 1, wherein heat is added to the reaction product from the first hydrogenation zone to raise the reaction product to a temperature of about 130°C to about

180°C prior to supplying the reaction product from the first hydrogenation zone to the second hydrogenation zone.

6. The process of claim 1, wherein the feedstream comprises maleic acid and at least one other hydrogenatable precursor.

7. The process of claim 6, wherein the hydrogenatable precursor is at least one of maleic anhydride, succinic acid, succinic anhydride, succinate esters, maleate esters, or gamma-butyrolactone.

8. The process of claim 1, wherein the ratio of hydrogen to maleic acid supplied to the process is between about 5 to 1 and about 1000 to 1.

9. The process of claim 1, wherein the operating pressure in each hydrogenation zone is independently between about 65 and about 300 atmospheres.

10. The process of claim 1, wherein the operating pressure in each hydrogenation zone is independently between about 100 and about 270 atmospheres.

11. The process of claim 1, wherein the contact time the operating pressure in each hydrogenation zone is independently between about 0.1 minutes and 20 hours.

12. A process for the production of at least one of gamma-butyrolactone, 1,4-butanediol and tetrahydrofuran comprising:

(A) a first hydrogenation zone and a second hydrogenation zone connected in series,

(B) supplying to the first hydrogenation zone at an inlet temperature of about 70°C to about 120°C a feedstream comprising maleic acid,

(C) reacting in the first hydrogenation zone, the maleic acid feedstock and hydrogen in contact with a catalyst to produce a reaction product comprising succinic acid,

(D) supplying to the second hydrogenation zone at an inlet temperature of about 130°C to about 180°C, the reaction product of the first hydrogenation zone,

(E) reacting in the second hydrogenation zone, the reaction product from the first hydrogenation zone and hydrogen in contact with a catalyst to produce a product stream comprising at least one of gamma-butyrolactone, 1,4-butanediol and tetrahydrofuran.

13. A process for the production of at least one of gamma-butyrolactone, 1,4-butanediol and tetrahydrofuran comprising:

- (A) a first hydrogenation zone and a second hydrogenation zone connected in series therewith wherein each hydrogenation zone independently contains a catalyst comprising a noble metal of Group VIII,
- (B) supplying to the first hydrogenation zone at an inlet temperature of about 70°C to about 120°C a feedstream comprising maleic acid,
- (C) reacting in the first hydrogenation zone, the maleic acid feedstock and hydrogen in contact with a catalyst to produce a reaction product comprising succinic acid and unreacted hydrogen,
- (D) supplying to the second hydrogenation zone at an inlet temperature of about 130°C to about 180°C, the reaction product of the first hydrogenation zone,
- (E) reacting in the second hydrogenation zone, the reaction product from the first hydrogenation zone and hydrogen in contact with a catalyst to produce a product stream comprising 1,4-butanediol.

14. The process of claim 13, wherein the noble metal of Group VIII for the catalysts in the first hydrogenation zone and the second hydrogenation zone are independently selected from the group consisting of palladium, platinum, rhodium and ruthenium.

15. The process of claim 13, wherein the catalyst in the first hydrogenation zone and the catalyst in the second hydrogenation zone, each comprise palladium.

16. The process of claim 13, wherein the catalyst in the first hydrogenation zone comprises palladium on a carbon support and the catalyst in the second hydrogenation zone comprises palladium, rhenium and silver on a carbon support.